International Social Research Nexus (ISRN)
ISSN (Online): 3105-0069

Research Article

Climate Change through Indigenous Eyes: A Case Study of the Santal Women in Bangladesh

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Article History
Received: March 16, 2026
Accepted: June 11, 2026
Published: July 1, 2026

Citation
Habiba, U., Razu, M. A. H. & Hossain, F. (2026). Climate Change through Indigenous Eyes: A Case Study of the Santal Women in Bangladesh. *International Social Research Nexus (ISRN)*, 2(2), 1-11. https://doi.org/10.63539/isrn.2026012

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Abstract

Climate change is a major problem for vulnerable people worldwide. It severely affects Indigenous communities whose livelihoods are closely connected to nature and agriculture. In Bangladesh, Indigenous women remain largely underrepresented in mainstream climate change discussions, despite their significant ecological knowledge and lived interactions with environmental change. This case study explores how Santal women in northern Bangladesh respond to climate variability through their traditional knowledge, cultural beliefs, and everyday environmental experiences. Fieldwork was conducted from January to April 2025.This study used a qualitative case study design to explore context-specific understandings of climate variability and its impacts. The study took place in Parbatipur Upazila of Dinajpur District. The area was selected due to a high population of Santals in the region whose means of living rely much on natural resources and agriculture. The data were gathered in the form of 25 in depth interviews (IDIs), four key informant interviews ((KIIs)) with the respected members of the community and four focus group discussions (FGDs), involving a total of 50 Santal women. Purposive sampling was used in selecting the respondents to provide diversity in terms of age, education and socio economic background. The collected data were analyzed using thematic analysis following Braun and Clarke's framework. The findings reveal that although many participants were unfamiliar with the scientific term "climate change". However, they clearly identified rising temperatures, irregular rainfall, shorter winters, seasonal disruptions, and crop failures through direct environmental observations. Their interpretations combined practical ecological understanding with cultural and spiritual explanations. For example, some participants linked climate change to divine displeasure or ancestral imbalance. This study also found generational differences in accessing modern climate information, including the use of smartphones and weather applications. However, younger women still depended on traditional ecological indicators, such as flowering patterns or bird calls. Additionally, climate variability has significantly affected agriculture, food security, health conditions, and cultural practices. It has increased women's vulnerabilities in everyday life as well. This study argues that Indigenous women's ecological knowledge should be incorporated into local and national climate adaptation policies. Specifically, the study recommends three actions. First, community-based documentation centers for traditional ecological indicators should be established. Second, Santal women should be included in union parishad climate committees. Third, Santal women should be trained as climate outreach workers. Greater inclusion of Santal women in climate decision-making, culturally sensitive adaptation programs, and improved access to climate information are also needed. Furthermore, Indigenous-centered development planning is essential. These steps can strengthen community resilience. They can also support cultural sustainability in climate-vulnerable regions of Bangladesh.

Keywords

Santal Women, Indigenous Knowledge, Climate Change Perception, Traditional Beliefs, Bangladesh.

1. Introduction

The problem of climate change is one of the most urgent global issues of the 21st century, and its impacts are extensive in the domains of the ecosystem and livelihoods, as well as health conditions of people. It is particularly severe in impoverished nations such as Bangladesh where large population levels, exposure to nature, and dependence on climate-dependent industries such as agriculture and livelihoods based on natural resources, exacerbate the risks (Nishat and Mukherjee, 2013; IPCC, 2019). In this regard, indigenous people are one of the most unevenly hit groups. One of the most interesting perspectives through which to explore the intersection of traditional worldviews and environmental change, the Santals one of the largest indigenous communities in northern Bangladesh, is included. The Santals inhabit mostly the districts of Rajshahi, Naogaon, Dinajpur, and Rangpur and their lifestyle is very close to nature (Sarker, 2014). Older generations of ecological knowledge are the key to their perception and reaction to environmental change. Of special concern is the experience of Santal women, who possess very crucial knowledge in interacting with natural resources in daily life. Being the primary collectors of water, firewood, wild food, and medicinal plants, they can be some of the first to notice changes in the natural patterns, including the change in seasonal patterns, rainfall, or biodiversity loss (Mandal et al., 2020).

The voices of indigenous women such as the Santals are mostly silent in the mainstream climate change debates but such narratives tend to be technocratic, male dominated and scientific in nature (Nakashima et al., 2012). Nevertheless, the understanding of the climate change does not arise only due to scientific data. Climate awareness in rural Bangladesh, where the insufficient formal education and scientific literacy might be the root causes, is frequently based on experience and cultural traditions and is perceived through the eyes of the community (Nakayama et al., 2019; Alam et al., 2017). The knowledge and observations about the changes in the environment through the body of women, and their interpretation of changes by monitoring the rain patterns, change in temperature, or failure of crops provide a practical and insightful knowledge of the climate dynamics which are culturally embedded. This orthodox knowledge is finding itself at crossroads with outside factors. The interpretation of climate risks and climate response is being influenced by exposure to mass media, NGO programs, and government awareness campaigns by the indigenous communities (Fernández-Llamazares et al., 2015; Memon et al., 2025).

The study indicates that families enrolled in these initiatives have a greater tendency to recognize the risks in the long-term perspective and implement adaptive strategies (Shah et al., 2025). The combination of traditional knowledge with contemporary awareness can be made resilient, assuming that any local voices are considered in the climate policy and planning. However, indigenous groups in Bangladesh are still exposed to systemic marginalization. Santal people, especially, have been experiencing a historical failure to secure land, lack of accessibility to social services and insignificant representation in development programs (Barakat et al., 2008; Kabir et al., 2024). Climate change can only escalate these structural issues endangering subsistence agriculture, diminishing biodiversity that is vital to traditional medicine, and aggravating food and water insecurity. Consequently, the Santal families have been either forced to wage labor or migrated seasonally as farming becomes unproductive (Miah et al., 2013; Akhter et al., 2013).

The stress of these developments lies heavily on Santal women. They are already at a disadvantageous situation due to their gendered expectations and mobility, as well as the lack of culturally-appropriate healthcare, and now have the additional burdens of climate-related health risks. Women are feeling the climate crisis both as an environmental degradation phenomenon and as an embodied and personalised threat by not only causing waterborne illnesses and respiratory problems but also maternal health complications (WHO, 2014; Kapaeeng Foundation, 2021). Although the importance of indigenous knowledge and climate adaptation is increasing, a significant difference in gender-specific research still occurs. In particular, the way indigenous women are affected by climate change and come up with coping mechanisms. The existing limited research studies tend to ignore the overlap between cultural values, traditional roles, and social inequalities and the experience of environmental change by women. This study aims at bridging this gap, as it targets the understanding of the perception of climate change by Santal women in northern Bangladesh.

The purpose of the study is two-fold as it seeks to address the following questions firstly, how the traditional ecological knowledge and lived experience influence the interpretation of climate variability and its effects by indigenous women and secondly, how these interpretations impact their reactions to health-related and environmental issues. Through emphasizing the subtle wisdom of Santal women, this study is intended to help add more inclusivity and cultural sensitivity to a more indigenous understanding of climate adaptation as, perhaps more importantly, a standalone resource to climate resilience in the present.

2. Literature Review

Indigenous knowledge is commonly understood as a knowledge system that is locally grounded and is passed through generations to enable communities adjust to their surrounding and to overcome their weak points. It is not a set of ideas but it is a dynamic process in which internal innovation and external influence develops (Flavier and Navarro, 1995; Brascoup and Mann, 2001). It is often qualitatively holistic and spiritual in nature in societies where individuals are directly reliant on natural resources like in rural and indigenous contexts, which are often associated with strong ties to land, water, and ecology (Gaillard and Mercer, 2013). Perception is as significant in determining how community responds to climate change. According to Van den Ban and Hawkins (2000), perception refers to the process through which the environmental cues get received and processed into a meaningful awareness. The perception studies conducted in Bangladesh indicate that the level of awareness regarding climate change is comparatively high with a wide range of awareness among different communities. As an example, it has been found that the common beliefs among the people are that climate change is associated with flood, cyclones, or drought, although it may be related in some ways to either human activities or nature or God (The Asia Foundation, 2012; Akanda and Howlader, 2015). Education is also a major factor that has been considered in the manner in which people conceptualize climate risks (Haq and Ahmed, 2017).

Comparative studies outside Bangladesh indicate that everyday experience is usually the basis of perception. Shukla et al. (2016) discovered that in India, most of the households perceived climate change in terms of increased temperatures and irregular rainfall, whereas Mekonnen et al. (2017) in Ethiopia found that locals viewed increased temperatures and erratic rainfall in line with meteorological expectation. These results indicate that native understandings of climate change are culturally sensitive as well as complementary in scientific knowledge. Even Bangladesh is one of the most climate-sensitive states that can be found globally. In the form of floods, cyclones, river erosion, and droughts, there is a constant destruction of livelihood, infrastructures, and displacement of communities (Karim & Mimura, 2008; Shahid & Behrawan, 2008).

The households that are mainly reliant on agriculture are especially vulnerable, as they experience reduced yield and migration following salinity, coastal erosion and unreliable rainfall (Alam et al., 2017). A significant amount of research, however, in the country and abroad, tends to provide generalizations about these forms of vulnerability, but rarely looks at the differences in the impact of these forms on indigenous communities (Ford, 2012; Rahman et al., 2018). This exclusion is very remarkable in the example of the Santal, one of the most numerous indigenous communities in Bangladesh. Agriculture, forests, and local ecosystems are an integral part of their lives and, therefore, they are very sensitive to climatic stresses. However, mainstream climate literature, according to Ahmed (2006) and others, tends to ignore that marginalized communities such as the Santals have a different set of problems. Women have a rather key role in such communities.

Floods, droughts, and unreliable rains are likely to impact Santal women, who are usually involved in farming, food processing, and water collection (Sorker, 2014). In addition to these practical duties, indigenous women are the keystones to ecological knowledge and transmit sustainable land management practices and agriculture techniques that have been perfected over generations. Their connection with the land, both culturally and spiritually, also affects environmental stewardship, which determines not only the everyday adaptation but also the larger activism (Chakraborty, 2024). Collectively, the available literature helps to make two significant points. First, local knowledge provides useful information on climate adjustments and the impressions of the local communities tend to be in line with the scientific findings. Second, even though the vulnerability of Bangladesh to climate change has been well-documented, the disparate impacts of the indigenous communities, especially women have not been well investigated in the literature and policy. This distance is essential because by putting emphasis on the voices of Santal women, not only does it expose the gender aspects of climate change but it also helps in more accommodating policy guidelines.

3. Methodology

This work is a part of a larger study conducted by the first author (Habiba, 2025). This study was conducted in a Santal village located in Parbatipur Upazila of Dinajpur District in northwestern Bangladesh. The area was purposively selected because it contains a significant Santal population whose livelihoods are highly dependent on agriculture, natural resources and seasonal environmental conditions. According to local administrative records and community information collected during fieldwork, the village consisted of 35 households with a total population of 209 people, including 107 men and 102 women. The village represents a culturally significant Indigenous settlement where both traditional Santal spiritual beliefs and Christianity coexist. Among the 35 households, 10 households had converted to Christianity, while the remaining households continued to practice traditional Santal beliefs centered on ancestral spirits and nature-based

spirituality. This cultural diversity provided an important context for understanding how environmental change, spirituality, and social life intersect in shaping climate change perceptions among Santal women. This study adopted a qualitative case study design to explore the lived realities, perceptions, and cultural interpretations of climate change among Santal women. A qualitative approach was considered appropriate because the study aimed to understand subjective experiences, meanings, and community-based interpretations rather than measure variables quantitatively. The case study approach enabled an in-depth exploration of climate-related experiences within a specific socio-cultural setting (Yin, 2018; Stake, 1995). Fieldwork was conducted from January to April 2025. The study involved a total of 50 Santal women participants selected through purposive sampling. Purposive sampling was used because it allows researchers to select participants who possess relevant experiences and knowledge regarding the research topic (Patton, 2002). Participants were selected to ensure variation in age, marital status, educational background, occupation, and socio-economic condition. Among the participants, 25 in-depth interviews (IDIs) were conducted using an interview guideline consisting of open-ended and flexible thematic questions rather than a structured questionnaire. The interview guideline focused on participants' observations of environmental changes, seasonal variability, agricultural experiences and cultural beliefs. Additionally, 21 women participated in four Focus Group Discussions (FGDs), and four elderly women participated as Key Informants (KIIs). Focus Group Discussions were also conducted to facilitate free discussion and explore shared perceptions. These dialogues were tailored in accordance with the framework of Lederman (1990), where a clear introduction of the purpose of the study and ethics was made. Icebreaker questions were adapted to introduce participants into the conversation, after which more theme-specific questions were asked regarding changes in the environment, resource scarcity, and conventional coping strategies. The Key Informants were selected based on their social status, cultural knowledge, and long-term involvement in traditional community practices. These women were recognized within the community as knowledgeable individuals regarding traditional ecological knowledge, spiritual beliefs, and seasonal patterns. The demographic characteristics of the 50 participants are presented in Table 1 below. After the fieldwork was completed, all interview and discussion sessions were recorded using audio, transcribed word-for-word, and then analysed using thematic analysis, which is a common approach in qualitative research to identify and interpret patterns in data. The analysis was based on the six-step framework of Braun and Clarke (2006), including familiarizing myself with the data, generating initial codes, developing themes, reviewing and refining themes, defining and naming themes, and producing the final report.

Ethical principles were strictly maintained throughout the research process. Prior to data collection, participants were informed about the purpose and objectives of the study. Informed verbal consent was obtained from all participants before conducting interviews and discussions. Participants were assured that their participation was voluntary and that they could withdraw from the study at any stage without any consequences. To maintain confidentiality and anonymity, pseudonyms were used in the manuscript, and no identifying personal information was disclosed. Additionally, as a non-Indigenous Bengali researcher, I acknowledge my positionality and spent two weeks in the village to build trust before formal data collection. I maintained personal field notes throughout the research process and continuously reflected on my cultural biases to ensure accurate interpretation of participants' experiences.

Table 1: Demographic characteristics of participants (N=50)

Characteristic	Category	Number (n)	Percentage (%)
Age group	25-35 years	18	36%
	36-45 years	20	40%
	46-60 years	12	24%
Education	No formal education	35	70%
	Primary (class 1-5)	12	24%
	Secondary (class 6-10)	3	6%
Marital status	Married	42	84%
	Widowed	6	12%
	Divorced/separated	2	4%
Religion	Traditional Santal beliefs	32	64%
	Christianity	18	36%
Occupation	Agricultural labor	38	76%
	Housework only	8	16%
	Small business	4	8%

4. Results

4.1. Unfamiliarity with the Term "Climate Change"

One of the themes raised repeatedly in interviews was the unfamiliarity of the participants with the term of climate change. Nevertheless, such ignorance of the meaning of the popularly used vocabulary was not an indicator of the lack of awareness. Indeed, every participant reported vividly about major changes in the weather patterns, seasonal changes, and disturbances within the ecology. These are some of the findings that are directly related to the scientific concept of anthropogenic climate change.

As an example, Putul Murmu (40) said, *"I never heard of the term climate change, but I know the summer seasons are now warmer than they used to be, winters take just a few weeks, and the winter seasons are summer. This was not what happened when I was not that young."*

The same perception was also echoed by another participant, Panmoni Murmu (45) in one of the focus group discussions: *"We do not possess formal knowledge on climate change. But the weather is different-the whole world knows. Rainy season occupy less duration when we require sufficient water to farm, and too much heat is experienced in summer."*

The given statements are related to the meteorological data of northwestern Bangladesh, indicating the increase in temperature by about 1.2degC since 1970 and a 15 percent decrease in the duration of the winter (Bangladesh Meteorological Department, 2020). Surprisingly, these Santal women have experienced such changes first-hand, through direct work experience, which is exposure to a more severe sun, the anomaly of seasons, and the impact on agriculture and living conditions. In this context, Shita Tudu (35) also gave more information on how rain was unpredictable based on her thoughts about rain: *"There was a time when rainy season used to give natural rain, which is timely as per the season. We sow the seeds in good hope. the sky now either remains empty months in a row, or fills our fields in one day. We had the sudden rains last year, and the whole of our harvest was ruined."*

The story of Tudu mention an increasing uncertainty in the amount of rainfall, and the increasing number of extreme weather occurrences-that is also in line with climate expectations of the tropical monsoon areas (IPCC AR6, 2022). The perceptions expressed above show that Santal women, in their manifest experiences of embodying and having a close proximity to nature have a profound environmental awareness of environmental degradation. They will not be aligned with the language of climate science, but involve a precise and significant sense of ecological change. This practical knowledge based on agricultural practice, health, and community memory is a useful angle to the perception and management of climate change at a grassroots level.

4.2. Disruptions in Livelihoods and Erratic Rainfall

The changing climatic situation has significantly affected the livelihoods of Santal women, who are individually involved in cultivating agricultural land as external workers and food producers at home. They show how unpredictable rainfall, extended droughts and extreme temperatures have altered the conventional agricultural cycles, endangered food security, as well as their workloads every day. A large number of participants complained that the frequency with which they used to predict and plan cultivation is lost. The unpredictable rainfall causes seedlings to be planted either too early or at the end hence yielding low or no harvest. The amount of crops destroyed by heavy rains or extended dry periods has also increased and therefore the families are forced to buy their food at the market, which puts a strain on already limited incomes. This has not only impacted on the economic stability of these households but it has also influenced negatively nutrition, health and well-being. Sabitri Kisku (42**)** described how climate variability has complicated her ability to sustain her family's farming activities:

"Earlier, we knew when to till the land and plant seeds. The rains would come at the same time every year. Now, we wait and wait, and suddenly the rain comes too strong. Last year, our paddy field flooded, and we lost half of our crop. We had to buy rice for three months something we never had to do before."

The other respondent, Champa Hembrom (38), commented on the increase in temperature as a physical burden on agricultural labor:

"In the past, we worked under the sun the whole day. It was hot, but bearable. Now the sun burns our skin. After just a few hours, we feel dizzy. But we still have to finish the work because no one else will do it. I feel I am getting weaker every year."

These perceptions are symbolic of a wider truth in native communities. Climate change is not something that is practiced in abstract sense, it is an everyday struggle that defines how women cultivate food, raise families, and sustain their lifestyle. Their narratives demonstrate how the environmental change intersects with economic susceptibility and physical wellbeing, and create a gendered as well as structural image of insecurity triggered by climate change. Although they are denied a formal voice in policy discussions, Santal women prove to have a clear and close idea of how environmental degradation is taking away their ability to grow their own food, feed their families, and support their communities. This image is not merely an ecologically conscious image but is also an image of strength and adjusting to increased uncertainty.

4.3. Disruption of Seasonal Cycles

Among the most regularly reported experiences of the Santal women there was interference with the traditional seasonal cycles. Bangladesh has six unique seasons such as summer (Grishsho), monsoon (Borsha), autumn (Shorot), late autumn (Hemonto), winter (Sheet) and spring (Boshonto) of which each of them is traditionally predictable and of cultural importance (Banglapedia, 2021). Nevertheless, respondents stressed over and over again that these trends have become more disjointed, which brings confusion not only to the activities of the agricultural sector but also to cultural life. Marina Hajda (50) expressed her concern with a sense of disorientation: *"...it's hard to tell when one season ends and another begins. Earlier, we knew the signs of seasonal change...the flowers, the winds, the temperature. But now, summer stretches too long, and winter arrives late or leaves early. Everything feels mixed up."*

It is not only agriculture that is impacted by this mixing and uncertainties of seasons. Rituals, festivals, and social practices, which are related to certain seasons of the year, have also been broken leading to a weak cultural rhythm of living in the rural areas. Dulali Mardi (37) pondered upon the fact that changing seasons have changed their farming methods and made their day to day livelihood uncertain:

"We used to prepare our land after spring because we knew the rains would come soon. Now, we wait for the rains, but they come late or all at once. Last year, we planted too early, and the sun dried out our crops. The year before, we planted late but flood occurred resulting crop failure. How would we survive in future?"

The loss of predictability in agriculture as described by Dulali, was based on the cyclical occurrence of seasonal changes. This confusion has caused crop failures, poverty and greater psychological pressure among the women who have to manage food in their homes. Rina Hembrom (41) told about the inconvenience of seasons not only farming, but also such cultural celebrations: *"We celebrate 'Nabanna' when the new rice comes. But now the harvest is delayed or spoiled. It feels like nature itself is confused."* This perception addresses cultural impact of seasonal anomaly caused by climate. The changing agricultural calendar undermines the traditions of a community, killing the intergenerational memory and destroying the relationship between the land, time, and ritual. These stories also highlight the fact that the sense of seasonal disjunction is not merely one of weather conditions, but it is of the disintegration of a cyclical worldview which once gave a sense and meaning to everyday existence. These changes are sources of anxiety, threat to cultural continuity and enhance vulnerability of an already marginalized community to Santal women.

4.4. Rising Temperature and Extended Heat Period

The participants reported that there was an irregular increase in the temperature during all seasons, with a special focus on how summer heat and winter warmth have been stronger and unpredictable. This shifting thermal pattern has interfered with their day to day living and increased in their feelings of instability in the environment. Sujata Tudu (48) complained*: "...it is now warm in winter and the house is too hot to sleep at night."* Her remark is not only a physical discomfort but also her feeling of being disoriented as used to the expectations of the season, these are no longer being followed. Historically, winter in rural Bangladesh was a time of rest, a time of coolness to offset the scorching summer of the year. Its disappearance is symbolic to most of the participants who view it as a greater disruption of natural harmony. Taposhi Mardi (43) shared, *"Earlier, we used to wear thick shawls until February. Now by January, we feel like it's already summer. The sun burns even in the morning."* This story brings out the fact that the day to day activities, the routine of wearing clothes, and the time spent outside is being changed by more unpredictable weather. The heat is not merely a seasonal one but extends through months which were once regarded as being temperate. Sapla Soren (39**)** added another layer to

the experience: *"The children become sick very often now a day. If it is cold today, tomorrow it will be hot. We don't know how to save them from high temperature induced disease."* Her observation shows an indication of thermal variation to health problems particularly to children. The sudden changes in temperature make days hot and then cold or wet at a very fast rate and make it hard to adapt to and add to diseases such as fevers and colds. This is one of the signs that climate change has a direct effect on the wellbeing of Santal families. The Bangladesh Meteorological Department (2020) suggests that the average temperature of the country has risen by about 1.2 C in the past 50 years and significant warming occurred in the country in the northwestern regions. These regions, which have a lot of indigenous settlements, experience extended heat waves and condensed cold seasons.

4.5. Cultural Interpretations of Climate Change

Outside the daily effects of environmental change, Santal women perceive such changes in the context of their spiritual and cultural beliefs. To them, in their worldviews, seasonal patterns, water and heat are not just a natural or scientific occurrence. They are strongly connected with spiritual powers and moral law. Climate anomalies are usually interpreted as evidence of a Godly discontent or result of human sins and indicates a lack of the divine order between humanity and nature. An example of such an opinion is the one that Panmoni Murmu (45) holds though she does not know the term climate change, she feels that changes in her surrounding are spiritual : *"...the rain doesn't come when it used to. Crops don't grow well, and the sun is so strong that it is hard to work outside. We don't have enough water even to bathe or cook properly. I think the gods are unhappy with us."* Her understanding is an ideology of believing that environmental disturbances are a divine reaction to human deeds- an ideology based on indigenous cosmology of understanding nature as a living creature that must be revered and admired. Romela Soren (50) offered a similar interpretation.

"Our ancestors said that the God gets angry when people forget rituals or pollute the land. Now the soil is dry, the rivers are low, and people are sick more often. Maybe we are not living the right way anymore. Nature is punishing us."

Romela also associates environmental degradation with loss of cultural values and destruction of customs. Her remark has an aspect of morality in the environmental change where the loss of a nature balance is perceived as a cultural and ecological crisis. Similarly, Chuni Kisku (39) explained the recent climatic changes with reference to the supernatural powers: *"we used to have festivals for good harvests, and the rains always came. Now, even when we perform rituals, the weather does not accept our prayers. It feels like the spirits are silent or angry with us..."* This faith is a manifestation of religious alienation, which associates climatic insecurity with the shift of culture and the decline of traditional practices. Chuni remarks illustrate the emotional and existential aspects of the climate perception, particularly to communities that perceive identity and security in terms of land, ritual and ancestral advice. All in all, these attitudes serve to show that to Santal women, the cultural meanings cannot be distinguished by the environmental perception. Although their explanations can be inconsistent with scientific explanations, they are an expression of a strong environmental awareness an awareness that combines spiritual ethics, the intergenerational memory and a strong sense of respect toward nature. These cultural understandings are critical to learn how the indigenous communities perceive and react to the climate change reality.

5. Discussion

The findings of this study show that Santal women possess a strong practical understanding of climate change even though most of them are unfamiliar with the scientific term itself. Their understanding comes from daily interaction with nature, agricultural work, seasonal observation, and lived experience. Participants described rising temperatures, irregular rainfall, shorter winters, droughts, and crop failures based on what they directly experience in their everyday lives. This finding supports earlier studies which argue that climate awareness in rural and Indigenous communities is mainly experience-based rather than dependent on scientific knowledge (Alam et al., 2017; Rahman & Alam, 2016). Similar findings were identified in India, where rural communities understood climate change through changes in rainfall and temperature patterns observed in daily life (Shukla et al., 2016). Therefore, the findings suggest that Indigenous ecological knowledge remains an important source of environmental understanding. Recent studies on Indigenous communities in Bangladesh strongly support the findings of this study. Datta and Kibria (2025), in their study on the Garo Indigenous community, found that climate change is causing land-based cultural erosion among Indigenous women. Their study showed that traditional jhum cultivation is gradually disappearing because of environmental instability and land loss. The present study reflects a similar situation among Santal women in northern Bangladesh. Participants explained that irregular rainfall, extreme heat, and changing seasonal patterns have disrupted traditional farming practices and reduced their ability to predict cultivation periods. As a result, agricultural uncertainty is increasing, which directly affects food security and traditional ways of life. Due to gendered roles in farming, water collection, and caregiving, Santal women

face distinct vulnerabilities. Akter and Roy (2024) highlight socio-economic vulnerability, and this study adds a gendered perspective: women experience multiple, simultaneous forms of marginalization as Indigenous people, women, and caregivers. Yet they show resilience through traditional knowledge and cooperation. Assaduzzaman et al. (2023) and Roy et al. (2022) note limited access to resources and decision-making for ethnic minority women, a pattern echoed here. Seasonal disruptions threaten cultural practices like Nabanna, causing emotional and cultural insecurity. Similar observations were made by Tirivangasi and Kontinen (2025) among Indigenous communities in Zimbabwe, where people depended on traditional seasonal indicators such as flowering patterns, rainfall behavior, and animal movements because scientific climate information remained inaccessible. Another important finding of this study is the cultural and spiritual interpretation of climate change among Santal women. Many participants associated droughts, irregular rainfall, and declining harvests with divine displeasure, ancestral disconnection, or the neglect of traditional rituals. Such beliefs reflect Indigenous worldviews in which humans, nature, and spiritual forces are deeply interconnected. Nakashima et al. (2012) similarly argued that Indigenous understandings of climate are holistic and combine environmental observation with spirituality, morality, and cultural values. Therefore, these beliefs should not simply be dismissed as unscientific. Instead, they represent culturally rooted environmental ethics that influence adaptation practices and community resilience. The findings also support Debnath's (2023) argument that social marginalization, land dispossession, and cultural exclusion threaten Santal identity in Bangladesh. The present study extends this discussion by showing that climate change is accelerating cultural erosion among Santal women. Participants explained that disrupted harvest seasons, crop failure, and environmental uncertainty are weakening traditional rituals and cultural celebrations. Climate change therefore appears not only as an environmental crisis but also as a threat to Indigenous cultural continuity and identity. Similar patterns were identified in Datta and Kairy's (2024) study of Munda Indigenous women in Bangladesh. Their study found that Indigenous women face environmental insecurity, land-related vulnerability, and exclusion from adaptation programs while depending heavily on traditional ecological knowledge for survival. Likewise, Santal women in this study continued to rely on inherited environmental knowledge and collective memory despite increasing climatic challenges. Datta and Kairy (2024) recommended greater participation of Indigenous communities in climate policy and adaptation planning. The findings of the present study strongly support this recommendation and further emphasize that the lived experiences and ecological knowledge of Santal women should be incorporated into local and national climate adaptation strategies.

6. Conclusion

This study demonstrates that Santal women possess a profound experience-based understanding of environmental changes, formed not through formal scientific training but through their daily interaction with the land, inherited cultural traditions, and spiritual beliefs. For them, climate change is not a remote or intangible phenomenon but is perceived through direct effects on their bodies, households, and community way of life. Changes in weather patterns, irregular rainfall, and loss of seasonal indicators have disrupted agriculture, food security, and traditional rituals. These shifts have created a sense of vulnerability and disorientation, especially as their coping mechanisms are increasingly constrained by limited access to healthcare, land rights, and institutional support. However, despite marginalization, Santal women continue to rely on collective memory, inherited knowledge, and social networks to respond to these challenges, demonstrating remarkable resilience. This study recommends several actions for policymakers. First, traditional ecological knowledge should be integrated into local climate adaptation plans. Second, community-based documentation centers for Indigenous climate indicators should be established. Third, Santal women should be trained as climate outreach workers. Fourth, Santal women's representation in union parishad climate committees must be ensured. Fifth, culturally sensitive healthcare programs for Indigenous women should be developed. This study contributes to the Santal community in three ways. It documents and amplifies Santal women's voices. It provides evidence for culturally appropriate policies. It also creates a knowledge baseline for community-led advocacy. This study has several limitations. It was conducted in only one village. Therefore, the findings may not apply to all Santal communities. Future research should include multiple villages, cross-district comparisons, longitudinal tracking of traditional knowledge, and mixed-methods validation of Indigenous observations. Despite these limitations, this study makes a valuable contribution. It shows why Indigenous women's voices matter in climate discussions. It calls for inclusive and culturally aware climate policies in Bangladesh.

Declarations

Author(s) Contributions

Author 1 conceptualized and designed the study, conducted fieldwork and data collection, performed data analysis, and drafted the original manuscript. Author 2 supervised the research process, contributed to data interpretation and the-

matic analysis, and critically revised the manuscript for intellectual content. Author 3 assisted in data validation, contributed to the literature review, and provided critical revisions to the manuscript. All authors reviewed and approved the final version of the manuscript.

Acknowledgements

The authors would like to express their sincere gratitude to the Santal community of Dinajpur, Bangladesh, for their kind cooperation and valuable time during this study. Without their trust and willingness to share experiences, this research would not have been possible.

Funding

This study was not funded by any public or commercial sector agencies.

Conflict of Interest

The author declares no conflict of interest related to this research work.

Competing Interest

Authors have declared that no competing interests exist.

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